Branching Patterns and the Major Transitions of Evolution

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ABSTRACT:

I seek to show that from the standpoint of the major transitions of evolution, language and culture are *non-genetic* mechanisms for increasing the number and differentiation of qualities across individuals in the human species (*including increasing the number of dissimilarities and categories of similarities across individuals in the human species)*. Thus, from the standpoint of functional perspectives in the behavioral sciences, sociobiology, and evolutionary psychology that ask "what does culture do?," or "what does language do?," language and culture increase the number and differentiation of qualities across individuals in the evolution of the Genus *Homo* and the human species, and increase the capacity for assortative mating across categories of similar characteristics and categories of dissimilar characteristics. I seek to discuss this fundamental observation in relation to the generation of branching patterns of characteristics in the human species, and that the emergence of larger and more diverse branching patterns of characteristics in the evolution of the Genus *Homo* and the human species involve major transitions of evolution.

Keywords: branching patterns natural selection cloning major transitions evolutionary computing

Branching Patterns and the Major Transitions of Evolution

1. **Introduction**: **The Major Transitions of Evolution in Light of Comparisons of Clones and Natural Populations**: John Maynard Smith and Eors Szathmary comment that the 'major transitions' in the emergence of greater complexity in evolution extend from the simplest life forms, prokaryotes and eukaryotes, to the evolution and differentiation of complex organisms across species, and to the emergence of language and culture (including technology) in the human species. (1-7)

It is interesting to consider the major transitions of evolution in light of comparisons of populations of clones to the natural populations of species from which the clones are derived or taken. If an individual organism taken or selected at random is cloned to produce a population of clones or genetic identicals (such as a 1,000 or a 1,000,000), the distribution of characteristics of the species population would collapse in the generation of clones. In the human species, this would result in the distribution of characteristics across individuals in the human species collapsing or reducing in the population of clones; that is, the number and differentiation of faces and facial characteristics, body types and physical characteristics, and behavioral characteristics including intelligences, personality characteristics, and talents, collapsing in the generation of clones (what Charles Darwin called "the diversity of mental faculties" across individuals would be reduced in the generation of clones).

Assortative mating also would be reduced: This is because the number and differentiation of characteristics across individuals would be reduced in a generation of clones. That is, assortative mating across individuals with dissimilar characteristics and different categories of similar characteristics would be reduced in the generation of clones (compared to a random sample of the natural population) since all of the individual organisms would be, given the nature of genetic inheritance, identical clones. (Assortative mating includes mating and interaction of 'like with like' or mating across similar characteristics, and also mating and interaction across dissimilar and complementary characteristics, sometimes popularly referred to as 'opposites attract'). Comparing populations of clones and natural populations of species from which the

clones are derived, then, also enables the identification of assortative mating as a quantity. Since a major transition of evolution is the emergence of language and culture, it is interesting to recognize that culture increases the qualities across individuals in the evolution of species in the genus *Homo*, particularly in the evolution of the human species, thus increasing the number and differentiation of characteristics across individuals in the human species. Culture also increases assortative mating since culture increases the qualities across individuals, and thereby increases the categories of similarities and dissimilarities across individuals in the human species as the genetics and biology of the human species co-evolves with increases in culture.

The major transition of evolution involving the emergence of language and culture in the evolution of the genus Homo and the human species, then, involves increasing culture, increasing assortative mating, and increasing qualities across individuals; moreover, it involves a branching geometry of an increasing number and differentiation of biological and cultural characteristics, i.e., an increasing number and differentiation of faces and facial characteristics, body types and physical characteristics, and behavioral characteristics expressed in cultural patterns, i.e., an increasing number and differentiation of intelligences, personality characteristics, and talents.

2. **The Emergence of Language, Culture, and the Human Branching Pattern as Major Transitions of Evolution:** Darwin and Wallace established the pattern that there are constant or near constant slight variations across individual organisms within any species, and 20th and 21st century biology has established that variations across individual organisms in species are the result of mechanisms of genetic variability, i.e., genetic mutation, transposable elements, gene duplication, sexual reproduction, and recombination. Dobzhansky comments that the concept of genetic mutation applies to different types of genetic variability including point mutations, chromosomal mutations, insertions, deletions, inversions, and gene duplications. (8) *The major transition of evolution of the emergence of language and culture also may be described as involving non-genetic means for increasing the number and differentiation of characteristics across individuals in species*. From this point of view, the major transition of evolution of the emergence of language and culture involves the emergence of a new kind of branching pattern in the evolution of life: the branching pattern or series of branching patterns of an increasing number and differentiation of

faces and facial characteristics, body types and physical characteristics, and intelligences, personality characteristics, and talents, is not only a branching pattern expressing biological characteristics but also a branching pattern of characteristics that are expressed biologically and culturally, i.e., intelligences, personality characteristics, and talents. All or virtually all biological species involve branching patterns of characteristics across individual organisms or branching geometries of characteristics across individual organisms that are the result of mechanisms of genetic plasticity and mutation (and these branching patterns are collapsed in generations of clones); however, in the case of the genus *Homo*, the branching pattern or branching geometry of the genus *Homo*, including the human species, is the result of mechanisms of genetic plasticity and mutation, and also culture and language.

Branching patterns are fundamental to science, their simulations in computer science, and many phenomena are considered or classified as branching patterns, including crystals, electric discharges, the tree of life, cellular differentiation and growth of organisms, branching patterns of characteristics across individual organisms, branching patterns of characteristics, adaptive structures, and adaptive properties across species, languages and linguistic groups, religions and religious sects, and also organizations, families, and human societies.

From the standpoint of the field of "astrobiology" and "bioastronomy," the major transition of evolution involving the emergence of language and culture as non-genetic means for increasing qualities across individuals, and also involving the emergence of a branching geometry of an increasing number and differentiation of faces and facial characteristics, body types and physical characteristics, and behavioral characteristics including intelligences, personality characteristics, and talents, is part of, in the words of Kardashev and Strelnitskij, "the progressive evolution of matter in the universe." (9-11)

3. **Functionalist perspectives ask, what does language do?** (12-14) **Or, what does culture do?** (6-7, 15-18) *Language and culture are non-genetic mechanisms or means for increasing the number and differentiation of qualities across individuals in the human species, and language and culture also increase the capacity for intraspecific assortative mating across individuals in the human species (by increasing the number of dissimilarities and categories of similarities across individuals in the human species).*

It is interesting to consider functional analogies amongst animals and plants: Birdsong and feather colors and plumage in bird species, and the colors and shapes of angiosperm flowering plant species play similar functions in these species, i.e., they increase the number and differentiation of characteristics across individual organisms, thus increasing the capacity for assortative mating across individual organisms in bird species (*intraspecific* assortative mating), and increasing the capacity for assortative mating across angiosperm species and insect species, bee species, and bird species (*interspecific* assortative mating).

4. **Populations of Clones and the Nature of Natural Selection**: *In a generation of a population of clones or genetic identicals, opportunities for natural selection are absent* since there are no genetic differences across individual members of the population. Consequently, given the identification of assortative mating as a variable, it is interesting to recognize that in species that reproduce by sexual reproduction, the forces of genetic mutation, gene duplication, and recombination increase the capacity for assortative mating across organisms in species since genetic mutation, gene duplication, recombination, and sexual reproduction increase the number and differentiation of characteristics across individuals. Culture increases the capacity for assortative mating across individual organisms more spectacularly in the human species: The emergence of culture is recognized as a major transition of evolution in the evolution of species, and *culture increases assortative mating since culture increases the number and differentiation of qualities across human individuals*. Thus, in the evolution of the genus *Homo*, culture and assortative mating have been increasing in the major transition of evolution involving the emergence of culture and language.

In contrast with genetic mutation, gene duplication, recombination, and sexual reproduction, (natural forces that increase the number and differentiation of characteristics across individuals in species), natural selection, in any generation, tends to decrease the number and differentiation of characteristics across individuals in species. Darwin and Wallace established the theory of evolution by natural selection, i.e., that given constant or near constant slight variations in the characteristics of individual organisms of species, less favorable variations or potential adaptations for survival and reproduction will be eliminated, and more favorable variations or potential

adaptations will be selected and retained. As Darwin recognized, natural selection is a conservative force that explains the gradual nature of evolution ("Natura non facit saltum"), and explains the conservation or retention of adaptive structures (19-20); thus, genetic mutation, gene duplication, recombination, and sexual reproduction are forces that tend to increase the rate of evolution in any given generation in contrast with natural selection. However, natural selection may "increase" the rate of evolution over generations by conserving or retaining adaptive structures that facilitate an increase in the rate of evolution and species diversification (cf. 21-24), like the the retention of bilateral symmetry, the retention of sexual reproduction, the retention of vertebrata, the retention of warm blood, the differentiation of forelimbs from hindlimbs, the retention of pollinating flowers, the retention of mammary glands, or the retention of organisms with larger and more complex brains.

5. **On Natural Selection and the Forces of Evolution**: The emergence of such adaptive structures are not generated by natural selection per se, but may be generated by creative forces such as genetic mutation, gene duplication, sexual reproduction, and recombination, in conjunction with natural selection, or in conjunction with natural selection and assortative mating. What shapes and organizes biological variation? Natural selection and assortative mating are forces that shape and organize biological variation produced by genetic mutation, gene duplication, sexual reproduction, and recombination. Biological variation that involves *assortative mating* in addition to natural selection may have faster rates of evolution (humans have faster rates of evolution than primates, and Darwin called the faster rate of evolution of angiosperm plants an "abominable mystery"), and may have more complex and larger branching patterns or branching geometries of characteristics (like species of angiosperm plants and the human species) than the biological variation of species that are shaped only or largely by natural selection.

Given genetic variability and inheritance, natural selection shapes branching patterns within and across species. Assortative mating also generates and shapes branching patterns within and across species, though assortative mating may generate more complex and larger geometries of characteristics than natural selection on its own.

Thus, natural selection shapes and organizes genetic and biological variation, and assortative mating also shapes and organizes genetic and biological variation. That

assortative mating shapes and organizes genetic and biological variation in addition to natural selection is potentially a new avenue for research in the biological sciences.

It has not escaped the notice of the present author that, since Darwinism or natural selection has been used as a design model or "design process" in robotics and computer science to generate patterns, artificial intelligence, and the retention of machine learning (24-28), in principle, assortative mating may be used as an alternative model or design process in robotics and computer science for the generation of patterns, artificial intelligence, the performance of simulations, and the generation of different types of machine learning.

Moreover, since computer science and different branches of science and engineering have been doing simulations of branching patterns since earlier in the 20th century, it may be highly useful to different branches of science, engineering, and computer science to use the techniques for predictive science introduced in this paper to reduce or collapse branching patterns in natural populations, and more easily visualize and identify branching patterns and their properties; moreover, it is also possible to consider how the properties of the individual organisms (or units of some other natural population) taken or selected at random from some natural population of organisms or units, may differ in some respects from the branching pattern of characteristics of the larger natural population from which they are taken or selected, and thereby be used to set the conditions for the emergence of new branching patterns compared to the natural population from which they were derived, taken, or modeled.

6. **Biochemist Nick Lane comments that natural selection is not "explanatory"**: Nick Lane comments that natural selection is not "explanatory" like general laws or principles in physics or chemistry. (29) However, the view expressed here is that natural selection is explanatory in that it explains, as Darwin emphasized, the conservation or retention of adaptive characteristics and the gradual nature of evolution. This is because, as Darwin and Wallace established in the theory of natural selection, given constant or perpetuating variations across individuals in species, (and given some mechanism of genetic inheritance that Darwin and Wallace postulated), variations more favorable for survival and reproduction are more likely to be conserved or retained. However, since natural selection is treated as a constant or near constant in its application across species and also within species, and is treated as a constant or near

constant in its application across sexually reproducing species and within them, its explanatory nature is limited in some contexts as Nick Lane (amongst others) suggests. For centuries, physicists have recognized that "it is not possible to explain a variable with a constant."

7. What Generates and Shapes Branching Patterns in Species and Biological Systems?

As suggested in earlier sections, natural selection shapes branching patterns, and natural selection in conjunction with genetic mutation, gene duplication, sexual reproduction, and recombination generates and shapes branching patterns.

Assortative mating generates and shapes branching patterns, and may generate and shape more complex branching patterns or larger branching geometries of characteristics in biological systems than natural selection on its own. Thus, assortative mating and natural selection in conjunction with the forces of genetic mutation, gene duplication, sexual reproduction, and recombination generate and shape branching patterns in biological systems and within and across biological species.

Cloning? Cloning produces branching patterns when there are multiple lines of clones that may be differentiated across functions, as in multiple cell lines that differentiate into the different cell types, tissues, organs, and adaptive structures of complex organisms, or the multiple kinds of cloned individuals of some eusocial insect species that fulfill different functions across the eusocial organism. (Major transitions of evolution have included new cell lines and new cell types that have emerged as new adaptive structures in the evolution of species).

Susumu Ohno suggests that gene duplication is more important for the emergence of new gene functions than point mutations and mutations at the level of genes and alleles. (30) Gene duplication is analogous to cloning, and it is possible to re-state Susumu Ohno's conjecture in a new way. Ohno's view is in effect that the differentiation of gene functions by gene duplication and genome duplication is greater than by genetic mutation per se (i.e., point mutations or mutations affecting the expression the individual genes and alleles).

From this standpoint, gene duplication produces branching patterns in the evolution of species, i.e., the differentiation of gene functions by gene duplication and genome duplication produces branching patterns of (new) adaptive structures in the evolution of species. Ohno's view may be re-stated: the differentiation of gene functions by gene duplication and genome duplication is greater than by genetic mutation, and the emergence of branching patterns of adaptive structures in the evolution of species are greater by gene duplication and genome duplication than by genetic mutation.

Moreover, from Susumu Ohno's standpoint, major transitions in evolution have emerged more from gene duplications than by genetic mutation. That is, major transitions of evolution have emerged more from the differentiation of gene functions by gene duplication and genome duplication than by genetic mutation, and the emergence of new adaptive structures in the evolution of species and branching patterns of adaptive structures in the evolution of species have happened more by gene duplications and genome duplications than by genetic mutation.

8. **Consequences of Cloning, Patterns of Co-Evolution, & the Exposure of Species Populations to Natural Selection**: As suggested, it is interesting to recognize that *in a generation of a population of clones or genetic identicals, opportunities for natural selection are absent* since there are no genetic differences across members of the population. Thus, in asexually reproducing organisms, in which members of populations are in effect clones, and the mechanisms of variation are less than in sexually reproducing organisms (being limited to mutation and various kinds of gene duplication and polyploidy), evolution is comparably slower, and opportunities for natural selection are less. That is, then, there are more opportunities for selection in species with greater genetic plasticity and genetic variability, i.e., sexual reproduction and recombination, and also mutation and gene duplication (compared to purely asexual organisms, such as various species of plants and asexual bacteria). It is in principle possible to rank species in terms of their genomic capacity for generating genetic variability and plasticity ("evolvability"), and this may be related to ranking species in terms of their genomic capacity for exposing their species to natural selection.

That is, species that have higher rates of mutation (for example, humans and angiosperm species) expose their species to natural selection more than species that have lower rates of mutation (for example, prokaryotic organisms, eukaryotic

organisms, and asexually reproducing plants). Assortative mating also may play a role in increasing the rate of evolution and the degree to which a species exposes its population to natural selection. The "major transition" of the emergence of pollinating flowering plants, likely the result of gene duplications (31-33), enabled the co-evolution of angiosperms with insects, bee species, and bird species. Consequently, angiosperms have more *interspecific* assortative mating than ancestral varieties of plants (that is, angiosperms co-evolve with and participate in assortative mating with insects, bees, and birds, while *such interspecific assortative mating is absent in ancestral varieties of plants*).

Assortative mating also applies to the human species, though it is *intraspecific*, i.e., the human species has more assortative mating than primate species or other mammals. (Assortative mating based on communication within a shared language is absent in primates and animals, and assortative mating based on cultural similarities and cultural differences, or complementary characteristics, is absent or virtually absent in primates and animals).

In an earlier section it was stated that *the major transition of evolution of the emergence of language and culture may be described as involving non-genetic means for increasing the number of qualities across individuals in species*. The major transition of the emergence of language and culture, then, increases the number and differentiation of qualities across individuals in the human species compared to primates and other mammals, thus increasing the capacity for *intraspecific* assortative mating.

In species with higher rates of mutation and faster rates of evolution (such as humans and angiosperm species), *natural selection has conserved and retained genetic elements that have higher rates of mutation and more mechanisms for producing genetic variability* (again, compared to asexual species such as asexual prokaryotes, eukaryotes, or asexual plants that rely on mutation and types of gene duplication and polyploidy for genetic variability compared to species with sexual reproduction, recombination, and gene duplication).

9. "Every species is a transition of evolution, but not every species is a major transition of evolution": On Cloning, Branching Patterns, and Species Concepts: The presentation of this paper suggests additional species

concepts: There have been many species concepts (1-2, 8, 21-22, 25, 29), though a species also may be defined in terms of its distinctive branching pattern or branching geometry of biological characteristics: That is, a species is a branching pattern of biological characteristics across organisms in which the organisms may interbreed and contribute to their species' evolving branching pattern, but that do not interbreed, share genes, or contribute genes to the branching patterns of foreign species with separate branching patterns of characteristics (exceptions include prokaryotes that engage in horizontal gene transfer, and some plants that can assimilate genes and structures from species of plants with which they do not normally reproduce). The branching patterns of species are in constant motion, shaped by genetic mutation, potential gene duplications, sexual reproduction and recombination, and then also by natural selection, and possibly, assortative mating as well.

Every species is a transition of evolution, though not every species is a major transition of evolution; that is, though every species is a transition of evolution, not every species is a major transition of evolution or a species that introduces a set of genes or adaptive structure that is a major transition of evolution: some adaptive structures, and branching patterns or branching geometries of adaptive structures, apply and extend across classifications of species, as in different adaptive structures (like bilateral symmetry, eyes, or vertebrata or others) that may extend and apply across a genus, a family, an order, a class, phylum, or kingdom of species.

Biologists and biochemists do not always use a concept of a division of labor of genes; however, species also may be defined in terms of their division of labor of genes or functional differentiation of genes that contribute to and generate the branching patterns or branching geometries of characteristics distinctive to each species: that is, each species also has a distinctive division of labor of genes of which foreign species do not participate (exceptions include prokaryotes that engage in horizontal gene transfer, eukaryotes that engage in limited gene transfer, and some plants that are able to assimilate genes across species). Moreover, cloned organisms are only able to reproduce in the division of labor of genes and genetic material of the species of which they are a part; that is, clones, like other individual organisms of any species, are only able to reproduce and produce viable offspring within the division of labor of genes or functional differentiation of genes and genetic material of the species of which they are a part. (By comparison, cloned genes can function in other organisms, as in cloning genes

and inserting them in other organisms, such as bacteria, to enable the bacteria to produce new proteins).

Selecting individual genes from any organism and cloning them as genes collapses the division of labor or (hidden) pattern of functional differentiation across the genes and genetic material of any organism of any species. Thus, cloning individual genes from any organism collapses the division of labor across the genes and genetic material of organisms or (hidden) pattern of functional differentiation across the genes and genetic material of any organism of any species.

The division of labor or functional differentiation across genes and genetic material in organisms is greater than many geneticists and biologists expected, since many scientists predicted or expected larger numbers of genes for various species, including original estimations of 100,000 genes or more for humans. In 1999, John Maynard Smith and Eors Szamathy, in their work on major transitions of evolution, expected that there would be 60,000 to 80,000 genes in the human genome. (5)

When estimates of the number of genes was revised to approximately 30,000, J.M. Claverie commented in the journal *Science*: "That a mere one-third increase in gene numbers could be enough to progress from a rather unsophisticated nematode [Caenorhabditis elegans, with about 20,000 genes] to humans (and other mammals) is certainly quite provocative and will undoubtedly trigger scientific, philosophical, ethical, and religious questions throughout the beginnings of this new century . . . Neither the cellular DNA content . . . nor its gene content appears directly related to our intuitive perception of organismal complexity . . . About 10% of human genes might correspond to potential drug targets related to diseases of socio-economical importance. With only 3000 candidate genes to work from, i.e., 30 for each of the top 100 companies throughout the world, the pharmaceutical industry is facing a new challenge." (34, cf. 35)

The number of genes in the human genome has since been revised to approximately 20,000.

The human species has only about 20,000 genes but its division of labor of genes or functional differentiation of genes is considerably different than other species that have similar numbers of genes or even more genes: The human species has only about

20,000 genes, and it is said that the genetic material of humans differs from chimpanzees by only 1-2%, and other large primates by only 2-4%; however, the branching pattern or branching geometry of characteristics that the division of labor of genes of the human species produces is larger and more diverse than primate species. It is an interesting question of how to more precisely quantify the branching geometry of characteristics of the human species, of an increasing number and differentiation of faces and facial characteristics, body types and physical characteristics, and behavioral characteristics including intelligences, personality characteristics, and talents: this includes what Darwin called "the diversity of mental faculties," and what Mihaly Csikszentmihalyi and Howard Gardner and some contemporary scholars refer to as "multiple intelligences" or the diversity of intelligences expressed in or interacting with cultural patterns (17-18); however, *there is no question that this branching geometry of characteristics of the human species is more than 1-4% greater than the distribution of facial characteristics and behavioral characteristics of chimpanzees or related primates*. This also implies that a small genetic potential or a small amount of conserved genetic material in humans generates a larger and more complex branching pattern of characteristics than primordial sets of genes in primate species; this also may be the case with angiosperm plants, i.e., in angiosperm species a small amount of conserved genetic material generates larger and more complex branching patterns of characteristics than ancestral species of plants and non-flowering plants that may have more genes and genetic material than angiosperm plant species though fewer adaptive characteristics or smaller branching patterns of characteristics. This also may imply that there is a greater alternation of functions in genes in species with interspecific assortative mating and intraspecific assortative mating than species whose branching patterns of characteristics are shaped by natural selection on its own; that is, from the standpoint of Darwinism, natural selection explains the evolution of the human species, natural selection explains the evolution of primate species, and natural selection explains the evolution of the nematode worm; however, since natural selection is in effect a constant across species, what explains that the human species, with a more diverse and complex distribution of physical characteristics and behavioral characteristics than the nematode worm, has a similar number of genes as the nematode worm? The alternation of functions of genes in the genetic material of the human

species may be greater than in the nematode worm, even though both species have a similar number of genes, approximately 20,000.

The division of labor of genes and genetic material of a species makes a species a species, and, as suggested, that the number of genes of various species were considerably less than expected or predicted by many geneticists and biologists, including the human species, implies that the division of labor of genes and genetic material in the evolution of species is so developed that species more complex than others in their adaptive structures and behavioral characteristics (such as the human species) require as many or fewer genes than species with less complex adaptive structures and behavioral characteristics. Smaller numbers of genes than expected for various complex species imply more developed and efficient divisions of labor across genes and genetic material in species than expected. This also suggests that major transitions of evolution across species do not necessarily increase the number of genes, but re-organize and re-distribute genes to new functions or expanded (or even lesser) functions in the new species. Major transitions of evolution may involve greater alternation of functions of genes in the genetic material of species, and the greater alternation of functions of genes in the genetic material of species may reduce the number of genes required to produce a complex set of adaptive characteristics in species. (Genetic recombination and gene duplication events may contribute to the greater alternation of functions of genes than genetic mutation on its own).

It is thus possible to compare transitions of evolution from major transitions of evolution: All species are transitions of evolution, but not all species are major transitions of evolution: Assortative mating (and also gene duplications and whole genome duplication events) may play a greater role in major transitions of evolution in the evolution of species than natural selection on its own, or natural selection and genetic mutation (pertaining to genes and alleles) on their own.

10. **On Darwin's principle of "Natura non facit saltum," and the possibility of "macromutations" and "punctuated equilibria"**: It is possible to consider the materials in section 7 in relation to Darwin's principle of "natura non facit saltum."

Darwin invoked a principle of "natura non facit saltum" to emphasize that his theory of natural selection implied that evolution was gradual.

It sometimes appears that nature “makes leaps” by assortative mating: Darwin was concerned that the considerably faster rate of evolution of angiosperm plants did not fit his theory of natural selection, and its implication of the gradual nature of evolution. (Darwin called the faster rate of evolution of angiosperm species an “abominable mystery.”)

Whether or not the faster rate of evolution of angiosperm species compared to ancestral species of plants counts as overturning Darwin’s principle of gradualism and his use of the principle of “natural non facit saltum,” it is recognizable that assortative mating generates larger and more diverse branching patterns of characteristics than natural selection on its own, and also may accelerate the diversification of characteristics and size of the branching geometry of characteristics across organisms in species more than by natural selection on its own.

It also sometimes appears that nature “makes leaps” by gene duplications, and it is sometimes alleged that gene duplications and whole genome duplication events abrogate or overturn Darwin’s principle of gradualism and thus also his use of the principle of “natura non facit saltum.”

Magadum et al emphasize the importance of gene duplications and whole genome duplication events in the evolutionary record (31). Darwin and Wallace established that there are constant slight variations across individuals in species; evolutionary theory has viewed possible or hypothesized “macromutations” and “punctuations” and “punctuated equilibria” with suspicion because they do not fit with conventional Darwinist theory, and because macromutations and punctuations are viewed as likely to produce deleterious consequences for organisms. Whole genome duplication events that increase the potential for the differentiation of gene functions (and potentially the alternation of functions of genes) are hypothesized to contribute to the emergence of new species and higher taxa, such as the transition from invertebrates to vertebrates, and ancestral species of plants to angiosperms. Whole genome duplication events are not “macromutations” in that, in a generation in which gene duplication or whole genome duplication events take place, the number of adaptive properties or adaptive structures of any multi-cellular organism in a breeding population do not double or even increase by huge margins, that is, they do not increase by 100% or even 10% or 5% or 1% in generations in which whole genome duplications or

gene duplications take place. However, in the evolutionary literature, whole genome duplication events in effect take the place of concepts like “macromutations” and “punctuations” that do not refer to specific changes in the inheritable or genetic material of organisms. From this standpoint, gene duplication and whole genome duplication events facilitate an increase in the rate of evolution, speciation, and the evolution of higher taxa (in conjunction with natural selection, and in some cases, such as the evolution of angiosperm species, in conjunction with natural selection and assortative mating).

Whether or not gene duplications or whole genome duplication events abrogate or overturn Darwin’s principle of gradualism and the principle of “natura non facit saltum,” it is possible to re-consider Susumu Ohno’s conjecture: in the evolution of species gene duplications and whole genome duplication events may increase increase the differentiation of gene functions more than genetic mutation at the level of genes and alleles, and gene duplications and whole genome duplication events may increase the size and diversity of branching patterns or branching geometries of characteristics across organisms in the evolution of species more than by genetic mutation on its own.

11. On Darwin’s principle of “Natura non facit saltum” and the evolution of technology: Given that advances in biotechnology enable the movement or transfer of genetic information for organs, tissues, and other adaptive structures within or across species, it may be said that advances in biotechnology enable the overturning the Darwin’s principle of gradualism, or, as Darwin sometimes refers to it, the principle of “natura non facit saltum.”

However, some applications of genetic engineering to species, by reducing or replacing some genetic elements and adaptations with others in species, by attempting to standardize genetic variation within specific species or sub-species, or by attempting to eliminate genes that cause cancer or genetic diseases and disorders, may reduce genetic variability and plasticity of species, thus reducing the exposure of species to natural selection. Some types of genetic engineering and biomedical applications may reduce the rate of evolution over generational time by attempting to reduce the exposure of species to natural selection. Medical science has the potential to reduce the exposure of populations to natural selection, and also assortative mating, by attempting to

standardize genes across populations, eliminate genes for different purposes, or reduce genetic diversity in populations.

Do scientists, engineers, or governments claim that advances or applications of genetics and biotechnology increase or are used to increase genetic variability and phenotypic variability across individuals in species or sub-populations of species to increase the exposure of populations to natural selection? Scientists, engineers, and governments usually do not claim that advances or applications in biotechnology and genetics increase the exposure of populations to natural selection; instead, they may seek to justify various advances in biotechnology and the biological sciences in terms of their medical uses or pharmaceutical uses for replacing the natural immune systems of organisms with artificial immune systems provided by pharmaceutical companies, government agencies, hospitals, and doctors.

In principle, an alternative strategy for using genetic engineering and biotechnology is to seek to use biotechnology and advances in biotechnology to increase the exposure of populations of organisms to natural selection. It is possible to ask the question of how to use biotechnology to attempt to increase the exposure of populations to natural selection, such as by attempting to increase genetic variability in populations,

(This strategy is different than attempts to modify adaptations or insert adaptations in a single generation of organisms, or attempts to standardize genetic variation across organisms in species or varieties, identify and estimate the number of disease causing genes or disorder causing genes for medical or pharmaceutical purposes, or eliminate disease causing or disorder causing genes).

From the standpoint of classic Darwinism, advances in biotechnology, by enabling the movement or transfer of genetic information for tissues, organs, and other adaptive structures across species, enable an overturning of Darwin's principle of gradualism, the principle of "natura non facit saltum." However, from the standpoint of the revolutions of Mendel, Watson, and Crick, some applications of genetic engineering, by reducing or replacing genetic elements in species, or by attempting to standardize genetic variation within a species or sub-species, may reduce the capacity for assortative mating across individuals in species, and also may reduce the exposure of species and

species varieties to natural selection, thereby, paradoxically, reducing rates of evolution in species and varieties.

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